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(54) Pneumatic tyr for motor v hicl s

(57) A radial tyre comprises a tread formed by two superimposed layers 11, 12 of different rubber compounds, and has a H/L ratio smaller than 0.60, where H is the distance from bead core 3 to breaker edge 8 and L the maximum width of the tyre section, the compound forming the layer 11 having an index of hysteresis loss not greater than 0.01 Joules/c.c. at 25°C and not greater than 0.006 Joules/c.c. at 70°C. The compound of layer 11 may form 1/9 - 1/4 of the total tread thickness and may have a modulus of elasticity at 100% elongation not less than 15 kg/cm^2.

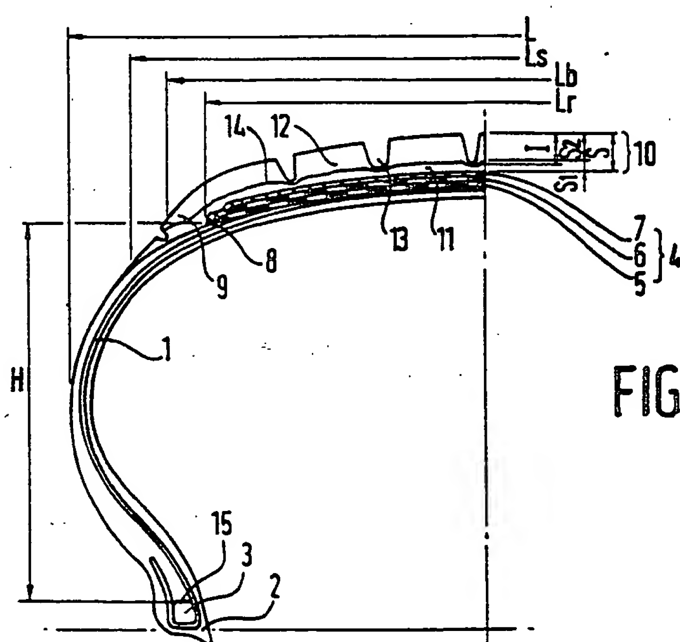

FIG.1

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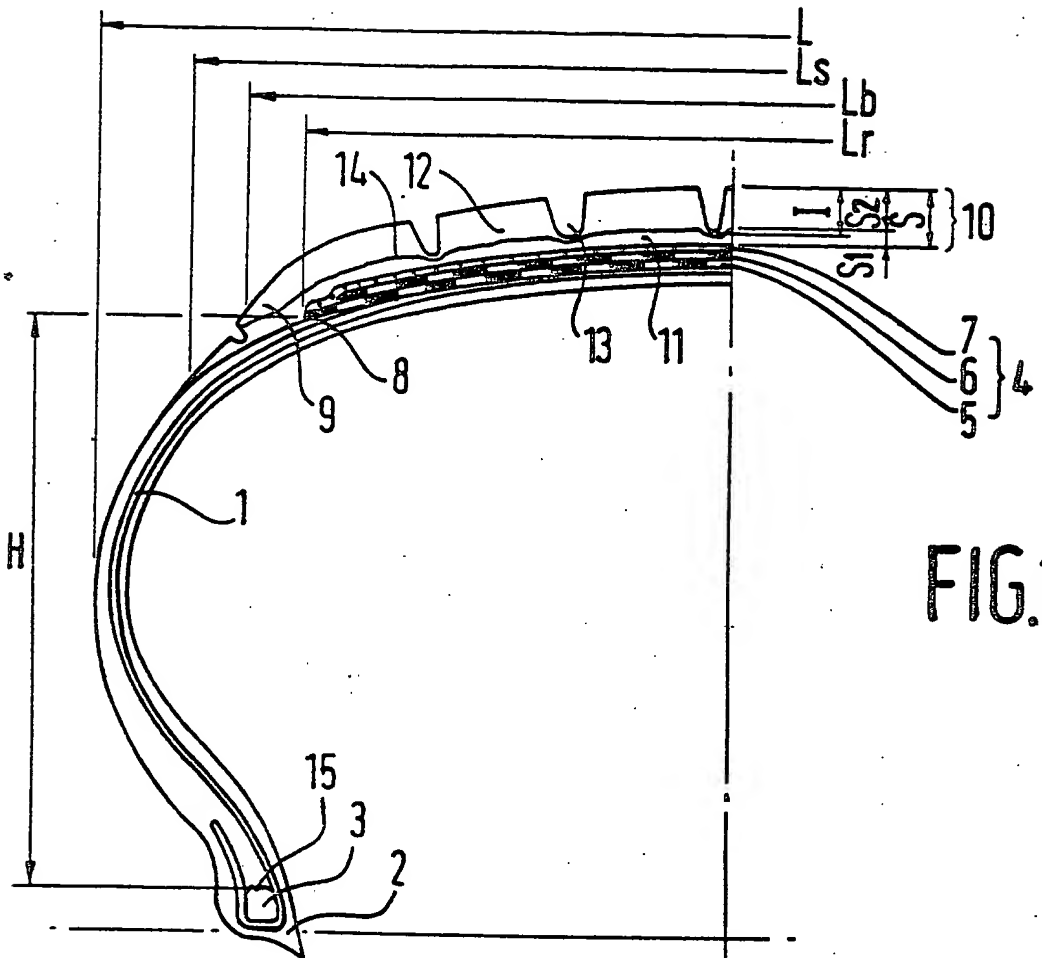

FIG.1

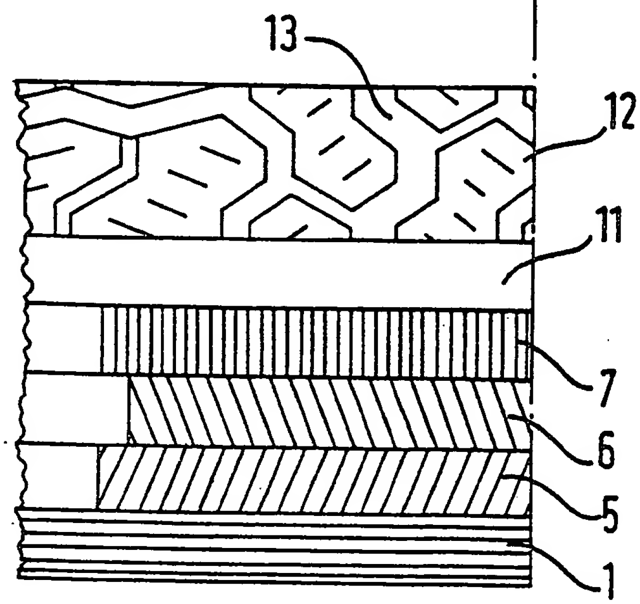

FIG.2

SPECIFICATION

Pneumatic tyre for motor vehicles having a low p wer absorption and a high directional control stability

The present invention concerns radial tyres for motor vehicles and more precisely it relates to radial tyres in which th carcass cords extend from one bead to the other, forming an angle of 90°, or angles slightly different from 90°, with respect to the mid-circumferential plane of the tyre.

In particular, the present invention relates to a radial tyre having a rolling resistance than that of conventional tyres, and therefore the tyre has a lower power absorption, which in turn results in a reduced fuel consumption for the motor vehicle.

It is known that a portion of the power absorption of the whole tyre is attributable to the tread, owing to the complex interaction occurring between the latter and the ground.

To reduce this power absorption, researchers have directed their efforts to the provision of various solutions, such as more appropriate patterns of the tyre or use of tread compounds having a low histeretic loss; however, although several solutions have given satisfactory results as regards power absorption, they have given rise to other problems which have resulted in failure to provide fundamental essential characteristics of a reliable tyre, for example a good resistance to tread tear, a good resistance to the small blocks tear, a good road traction on dry and wet ground and so on.

In order to find a solution which does not incur such problems, there have been devised composite tyres, where the tread is formed by two layers of compound radially superimposed to each other, the radially outermost layer (which forms the blocks and grooves of the tread pattern) being substantially characterised by a good resistance to abrasion, tear and cracks and by a good traction on dry and wet ground, and the radially innermost layer having as main characteristic a low hysteretic loss.

This solution provides a tread of the so-called "cap and base" type, and has given good results as regards the tyre power absorption, but without giving rise to excessive limitations of the tyre mileage, due to wear and trear of the tread. It also provides good traction on dry and wet ground. However, it has been found that such tyres have a low resistance to the transverse forces acting onto them, for instance on cornering, which originates problems regarding the tyre directional control stability, which are particularly important when the tyre runs at high speed.

Probably, said low resistance to the transversal forces is due to the fact that the low hysteretic loss of the radially innermost layer of the tread is accompanied by a greater deformability under stresses acting on it.

The Applicant has now found that it is possible to obtain a further reduction of the power absorption in a pneumatic tyre provided with a tread of the "cap and base" type by modifying the geometrical configuration of the carrying structure of the tyre itself, and that such a modification may also improve the directional control stability characteristics of the tyre.

The present invention aims at providing a pneumatic tyre having improved characteristics - with respect to conventional tyres - as regards power absorption and directional control stability.

Accordingly, the present invention provides a pneumatic tyre for vehicle wheels which comprises a carcass of radial cords, two sidewalls whose mutual maximum distance apart measured in the axial direction defines the section width of the tyre, two beads each of which comprises at least a bead core around which are wrapped the cords of said carcass, a tread situated at the top of the carcass, a circumferentially inextensible annular reinforcing structure radially interposed between said tread and said carcass, said annular structure having a width substantially equal to that of the tread and having lateral edges lying one at each tread shoulder, said tread comprising two layers of different rubber compounds radially superimposed upon one another, the tyre being characterised in that the compound forming the radially innermost layer has an index of hysteretic loss not higher than 0.010 Joule for each cubic centimetre of compound at a temperature of 25°C and not higher than 0.006 Joule for each cubic centimetre of compound at a temperature of 70°C, the ratio between the radial distance of the lateral ends of said annular reinforcing structure, from the radially outermost point of the bead core, and the width of the tyre section being smaller than 0.60.

It is to be noted that in the present specification the expression "hysteretic loss" means the loss of energy in each cubic centimetre of compound which is needed to deform a block of compound, by means of a compression force exerted in a given direction, till to 9/10 of its original dimension, said block being free from links in the directions transversal to said given direction, and then to allow the block to return to its original dimension, the cyclic deformation of the compound block and its return to the original size being carried out in about 1/50 of a second. The value of the hysteretic loss in respect of any considered compound may vary according to the temperature at which it is measured.

Preferably, said ratio is ranging between 0.40 and 0.60.

According to a preferred embodiment of the invention, the compound forming th radially innermost layer has an index of hysteretic loss ranging between 0.002 and 0.006 Joule for each cubic centimetre of compound at 25°C and ranging between 0.0015 and 0.004 Joule for each cubic centimetre of compound at 70°C.

According to a further preferred embodiment, the compound forming the radially innermost layer has a thickness not smaller than 1.2 mm and preferably ranging between 1/9 and 1/4 of the whole tread thickness.

It is to be noted that, in a cross-section of the tread, the separation line between the two layers of

compound is not parallel to the outer surface of the tread; more precisely, it is parallel to said surface in the zones comprised between two adjacent grooves. However, in proximity of the groove walls, it lowers as far as the groove bottom. It is anyhow understood that the above defined thickness values are referred to the portions of the separation line comprised between two grooves and therefore parallel to the outer surface of the tread.

According to a further preferred embodiment of the invention, the compound forming the radially innermost layer has a modulus of elasticity, at an elongation of 100%, which is not smaller than 15 kg/cm^2 and preferably ranges between 20 and 30 kg/cm^2.

The present invention will now be better described with reference to the attached sheet of diagrammatic drawings, given by way of example, in which:

Figure 1 represents the cross-section of a tyre according to one embodiment of the invention (only one half of said section being shown, as the other half is perfectly symmetrical to the first), and

Figure 2 represents in plan view the tread of the tyre shown in Figure 1 comprising a preferred annular reinforcement structure.

Figures 1 and 2 illustrate a car tyre in inflated condition, which comprises a carcass 1 constituted by cords lying in radial planes, namely forming 90° (or angles only slightly different from 90°) with respect to the mid-circumferential plane of the tyre. Said carcass extends from one head 2 to the other and turns up around the respective bead core 3.

A circumferentially inextensible annular reinforcing structure 4 is situated at the carcass top.

Said structure is formed by two layers 5 and 6 of metal cords directed at 18° and 24° with respect to the mid-circumferential plane of the tyre, the cords of one layer crossing those of the other; a third layer 7 of nylon cords, preferably oriented in the mid-circumferential direction of the tyre, is arranged on the metal layers 5 and 6.

The width of layer 6 is slightly smaller than that of layer 5 to allow a normal graduation between them; the width of layer 7 is of the same order as that of layer 5; however, the width of layer 7 could be greater or smaller according to the performance required to the tyre.

The width Lr of the whole annular reinforcing structure is shown of the same order as the width of the tyre tread, but it could differ from it slightly, therefore the lateral ends 8 of said annular reinforcing structure lie generally in correspondence to the shoulder 9 of said tread.

The tread 10, comprising two radially superimposed layers 11 and 12 of compound, is arranged in a radially outer position with respect to said annular reinforcing structure.

The layer 12, provided with the grooves and blocks which form the tread pattern, has a width which is the same as the width Lb of the tread; the layer 11 has a width Ls greater than that of layer 12 and is connected to the tyre sidewall by the possible interposition of suitable compound inserts, not illustrated in the drawing.

Alternatively, the widths of layers 11 and 12 could coincide; in that case the connection with the sidewall could be carried out by means of a compound insert.

The tread 10 is provided with grooves 13 having a depth l; the whole tread thickness is S, S being greater than l. The layer 11 has a thickness S1 not smaller than 1/9 of S, preferably ranging between 1/9 and 1/4, and anyhow not smaller than 1.2 mm.

The figure shows the separation line 14 between layers 11 and 12; said line has a zone, comprised between two adjacent grooves, which is practically parallel to the outer surface of the tread; in the region of said grooves the separation line lowers, reaching the groove bottoms. In this way, the groove bottom is formed of the same compound as that forming layer 12.

The measurement of the thickness of layer 11 is considered as effected at the zone comprised between two adjacent grooves, in which the separation line 14 is practically parallel to the outer surface of tread 10.

The layer 12 of the tread 10, intended to come into contact with the ground, is formed by a compound normally used to build up treads, namely one having a high resistance to abrasion, tear and cracks and good properties as regards traction on dry and wet ground.

By way of example, said compound can be made of SBR of various types, or of other polymers mixed with the latter.

Of course, the basic copolymer is compounded with those ingredients which are necessary to impart to the compound forming layer 12 the desired characteristics.

The following table indicates two examples of compounds suitable to form layer 12 of the tread, together with some physical characteristics evaluated on the compound in cured condition.

TABLE 1

The values are referred to parts by weight.

Compound	A	B
SBR with 25% styrene	50	-
SBR with 25% styrene, extended with 37.5 parts of oil	50	-
SBR with 40% styrene	-	100
Carbon black N 375	60	60
Mineral oil	10	12
Stearic acid	2	2
Zinc oxide	2	2
(Protective system) Antidegradent	2.5	2.5
Cyclohexylbenzylthiazylsulphenamide	1.8	1.0
Sulphur	1.4	1.4
ISO hardness	68	66
Elasticity modulus 100% (kg/cm^2)	22	16
Tensile strength (kg/cm^2)	180	160
Ultimate elongation (%)	480	510
Index of hysteretic loss at 25°C (J/cm^3)	0.045	0.060
Index of hysteretic loss at 70°C (J/cm^3)	0.020	0.025

The layer 11 of the tread 10 is formed of a compound having an index of hysteretic loss not greater than 0.010 Joule on each cubic centimetre of compound at a temperature of 25°C and not greater than 0.006 Joule on each cubic centimetre of compound at a temperature of 70°C; preferably, said index of hysteretic loss ranges between 0.002 and 0.006 Joule on each cubic centimetre of compound at 25°C and between 0.0015 and 0.004 Joule on each cubic centimetre of compound at 70°C.

The modulus of elasticity of the compound, at an elongation of 100%, is not smaller than 15 kg/cm^2 and is preferably ranging between 20 and 30 kg/cm^2.

The following table indicates three examples of compound suitable to form layer 11 of the tread and also reports some physical characteristics evaluated on the cured compound.

TABLE 2

The values are referred to parts by weight

Compound	A	B	C
Natural rubber	100	100	70
1.4 cis polybutadiene	-	-	30
Carbon black N 375	-	23	45
Carbon black N 660	35	23	-
Mineral oil	2	3	10
Stearic acid	2	2	3
Zinc oxide	4	4	4
(Protective system)Antidegradent	2.5	2.5	2.5
Cyclohexylbenzylthiazylsulphenamide	1	1.5	1
Sulphur	2.5	1.5	2
ISO hardness	62	64	66
Elasticity modulus 100. (kg/cm^2)	25	26	20
Tensile strength (kg/cm^2)	190	220	220
Ultimate elongation (%)	390	440	500
Index of hysteretic loss at 25°C ($Joule/cm^3$)	0.0025	0.0010	0.0050
Index of hysteretic loss at 70°C ($Joule/cm^3$)	0.0015	0.0025	0.035

The Applicant has found that the above-mentioned limit values of the hysteretic loss indexes represent critical limitations to the tyre performance, both as regards the problem of power absorption and as regards the resistance of the tyre to the lateral forces and consequently its directional control stability.

In fact, higher values do not originate appreciable improvements of the tyre power absorption, whilst lower values have as a consequence a reduced resistance of the compound to tears, with possible risks of ruptures, which are the higher the more uneven is the ground.

On the other hand, lower values result in a reduction of the elasticity modulus of the compound, so that the tread blocks show a lesser resistance to the deformations due to their interaction with the ground; therefore phenomena of irregular wear of the tread and/or of insufficient directional control stability of the tyre could be originated, which would be the more relevant the higher the tyre speed.

Still with reference to Figure 1, the tyre according to the invention has a section width L which is determined by the maximum axial distance existing between the two sidewalls of the tyre itself.

In general, said maximum width can be determined at a zone situated at about one half of the height of the whole cross-section of the tyre.

As described above, Lr represents the width of the annular reinforcing structure, namely the axial distance existing between the lateral ends 8 arranged on the carcass 1 at the shoulder 9 of the tread 10.

The radial distance betw en said lateral end 8 and the radially outermost point 15 of the bead core 3 is represented by line H (approximately, said distance could be called "sidewall height").

The ratio H/L of the tyre according to the invention is smaller than 0.60 and is preferably ranging between 0.40 and 0.60.

In the tyre shown in Figure 1, L is 185 cm, Lr 130 cm and H 81 cm, so that the H/L ratio is 0.43.

Some tyres according to the present invention have been tested in direct comparison with conventional tyres; the obtained results are reported in the following table.

TABLE 3

Tyre Series	Tread	H/L	Power absorption HP	Resistance to transversal forces-kg
I -	One layer of Compound A	0.65	1.4	130
II -	Two superimposed layers (outer one compound A - inner one Compound D)	0.65	1.2	110
III -	Two superimposed layers (outer one Compound A - inner one Compound D)	0.50	1.1	130
IV -	Two superimposed layers (outer one Compound A - inner one Compound E)	0.45	1.1	140

The power absorption and the resistance to the transversal forces were measured on a machine, well known to the tyre technicians, substantially formed by a driving wheel, commonly defined, "test drum", against which the tyre under examination is pressed under a given load; the axis of rotation of the tyre can be parallel to the axis of the driving wheel or inclined with respect to it. The machine measures the couples and the forces acting on the axis of the test drum and is provided with instruments for reading said parameters.

In particular, the measurement of the power absorption was carried out on a test drum having a diameter of 1.701 metres, rotating at a peripheral speed of 80 km/hour at 20°C, the axis of the tyre placed on the drum being parallel to that of the latter, the tyre being loaded for 90% of the maximum admissible load and being inflated at the pressure indicated by the manufacturer for said load, and the reading of the instrument being carried out when the tyre temperature had settled at a constant value.

The measurement of the resistance to the transversal forces was carried out in the same conditions and with the same method adopted for the preceding test; in this case, however, the tyre axis was inclined by 2° with respect to the axis of the test drum and the instrument indicated the entity of the thrust acting on the axis of the test drum.

Finally, the data reported in Table 3 are the average values obtained from the examination of a wide range of tyre samples of different types and sizes, all characterised by having the same H/L ratio.

The results show that the tyres of the first series have a high power absorption and a satisfactory resistance to the transversal forces.

The tyres of the second series show a power absorption substantially smaller than that of the first series tyres, but they have also a much lower and quite unsatisfactory resistance to transverse forces.

The tyres of the third and fourth series show a power absorption which is still lower than that of the second series tyres and have a resistance to the transverse forces which is of the order of that of the first series tyres.

As regards fuel consumption, the tests demonstrated that - the type of vehicle and the distance covered (about 100 km) being equal - the tyres of the third and fourth series originated a consumption of 8.25 litres, against 8.65 litres with the first series tyres and 8.38 litres with the second series tyres, with a respective saving of 4.6% and 1.55%.

The reasons for which the tyres according to the present invention have given the above reported results are numerous and perhaps not quite understandable.

A possible explanation given to improve the understanding of the invention but not in any way to limit it is given by the fact that - in equal service conditions - the tyres having H/L less than 0.60 have, at their sidewalls, a bending radius smaller than that shown by tyres in which H/L has a different value (for instance the tyres of the second series indicated in the abov table).

Consequently, the tension stresses exerted along the radial cords in the sidewall zone are smaller and at the same time the tension stresses exerted in the circumferential direction, in the zone of the annular reinforcing structure, are greater. Thus, the cords of said annular reinforcing structure are effectively stiffened and consequently show a reduced liability to deformations due to further stresses, whether these are exerted in the circumferential or in the transverse direction. In other words, such cords acquire a greater resistance to these stresses.

Such increased resistance to deformations is transmitted to the innermost layer of the tread and therefore also to its outermost layer, which is formed by the blocks and grooves of the tread pattern.

As a result, the whole tyre top portion (annular reinforcing structure plus the two tread layers) is enabl d to better withstand the transverse forces acting in the tyre, substantially improving the tyre directional control stability characteristics.

The higher resistance of the annular reinforcing structure to deformations provides a contact area of the tyre on the ground which has a reduced length in the direction of the tyre motion (the comparison being made - at equal service conditions - between the tyres of the present invention and tyres in which H/L is greater than the indicated value (for instance tyres of the second series reported in the above table).

Consequently, the distance between the point of maximum pressure below the tyre contact area in static condition and the point of maximum pressure at said area in dynamic condition (the latter point being always advanced in the direction of motion with respect to the former) is smaller.

In this way the resistant couple of the tyre is lower, with a lesser rolling resistance and therefore a smaller power absorption.

CLAIMS

1. A pneumatic tyre for vehicle wheels comprising a carcass of radial cords, two sidewalls whose mutual maximum distance apart measured in the axial direction defines the section width of the tyre, two beads each of which comprises at least a bead core around which are wrapped the cords of said carcass, a tread situated at the top of the carcass, a circumferentially inextensible annular reinforcing structure radially interposed between said tread and said carcass, said annular structure having a width substantially equal to that of the tread and having lateral edges lying one at each tread shoulder, said tread comprising two layers of different rubber compounds radially superimposed upon one another, the tyre being characterised in that the compound forming the radially innermost layer has an index of hysteretic loss not higher than 0.010 Joule for each cubic centimetre of compound at a temperature of 25°C and not higher than 0.006 Joule for each cubic centimetre of compound at a temperature of 70°C, the ratio between the radial distance of the lateral ends of said annular reinforcing structure, from the radially outermost point of the bead core, and the width of the tyre section being smaller than 0.60.

2. A pneumatic tyre for vehicle wheels as in Claim 1, characterised in that said ratio is between 0.40 and 0.60.

3. A pneumatic tyre for vehicle wheels as in Claim 1 or 2, characterised in that the compound of the radially innermost layer has an index of hysteretic loss between 0.002 and 0.006 Joule for each cubic centimetre of compound at 25°C and between 0.0015 and 0.004 Joule for each cubic centimetre of compound at 70°C.

4. A pneumatic tyre for vehicle wheels as in Claim 3, characterised in that the compound of the radially innermost layer has a thickness not smaller than 1/9 of the whole tread thickness.

5. A pneumatic tyre for vehicle wheels as in Claim 4, characterised in that the compound of the radially innermost layer has a thickness ranging between 1/9 and 1/4 of the whole tread thickness.

6. A pneumatic tyre for vehicle wheels as in any one of Claims 1-5 characterised in that the compound of the radially innermost layer has a modulus of elasticity, at an elongation of 100%, not lower than 15 kg/cm^2.

7. A pneumatic tyre for vehicle wheels as in claim 6, characterised in that the compound of the radially innermost layer has a modulus of elasticity, at an elongation of 100%, between 20 and 30 kg/cm^2.

8. A pneumatic tyre constructed and arranged substantially as described herein and illustrated in the accompanying drawings.

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